

Spectroscopic and Kinetic Measurements of Alkali Atom-Rare Gas Excimers

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Twelfth Annual Directed Energy Symposium
Directed Energy Professional Society
San Antonio, TX

November 4, 2009

Sponsored by HEL-JTO under a MRI Grant

Acknowledgement of Support and Disclaimer

This material is based upon work supported by Air Force Office of Scientific Research under Contract Number FA9550-07-1-0575. Any opinions, findings and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of Air Force Office of Scientific Research.

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Report Documentation Page				Form Approved OMB No. 0704-0188	
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1. REPORT DATE 04 NOV 2009		2. REPORT TYPE		3. DATES COVERED 00-00-2009 to 00-00-2009	
4. TITLE AND SUBTITLE Spectroscopic and Kinetic Measurements of Alkali Atom-Rare Gas Excimers				5a. CONTRACT NUMBER	
				5b. GRANT NUMBER	
				5c. PROGRAM ELEMENT NUMBER	
6. AUTHOR(S)				5d. PROJECT NUMBER	
				5e. TASK NUMBER	
				5f. WORK UNIT NUMBER	
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) Physical Sciences Inc,20 New England Business Center,Andover,MA,01810				8. PERFORMING ORGANIZATION REPORT NUMBER	
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)				10. SPONSOR/MONITOR'S ACRONYM(S)	
				11. SPONSOR/MONITOR'S REPORT NUMBER(S)	
12. DISTRIBUTION/AVAILABILITY STATEMENT Approved for public release; distribution unlimited					
13. SUPPLEMENTARY NOTES					
14. ABSTRACT					
15. SUBJECT TERMS					
16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT Same as Report (SAR)	18. NUMBER OF PAGES 24	19a. NAME OF RESPONSIBLE PERSON
a. REPORT unclassified	b. ABSTRACT unclassified	c. THIS PAGE unclassified			

Goals

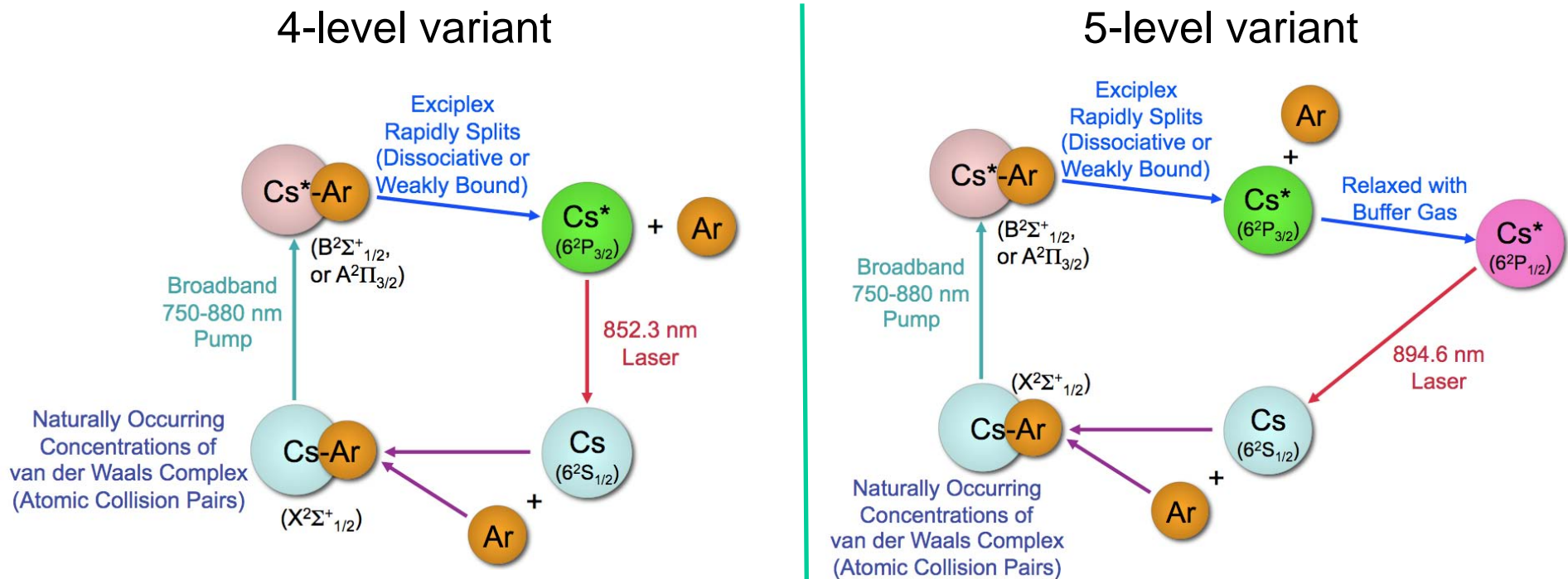
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- **Novel use of alkali/rare-gas molecules to efficiently couple high power diode arrays into alkali vapors**
 - Exciplex molecules absorb over much greater bandwidth
- **Control of inherent high optical gain to minimize ASE and optimize laser oscillation**
- **Development of large volume resonators that allow efficient power extraction**
- **Demonstration of high electrical-to-optical efficiency/power Exciplex assisted diode Pumped Alkali Laser (XPAL)**
- **Education of a future generation of laser scientists**

Novel Approach

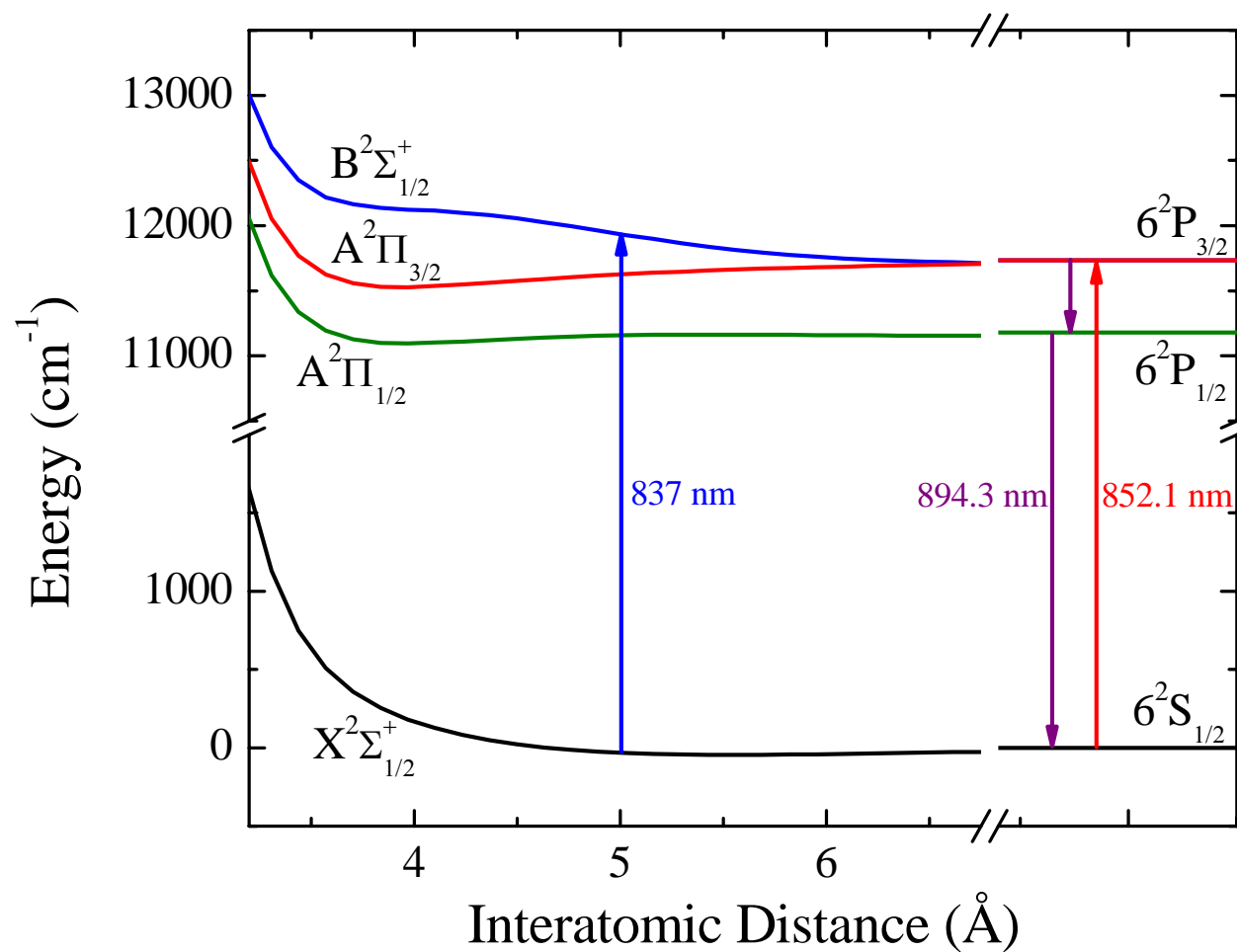
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- This new laser exploits the optical properties of weakly-bound alkali/rare-gas exciplexes for pumping the $^2P_{1/2, 3/2}$ alkali atomic excited states



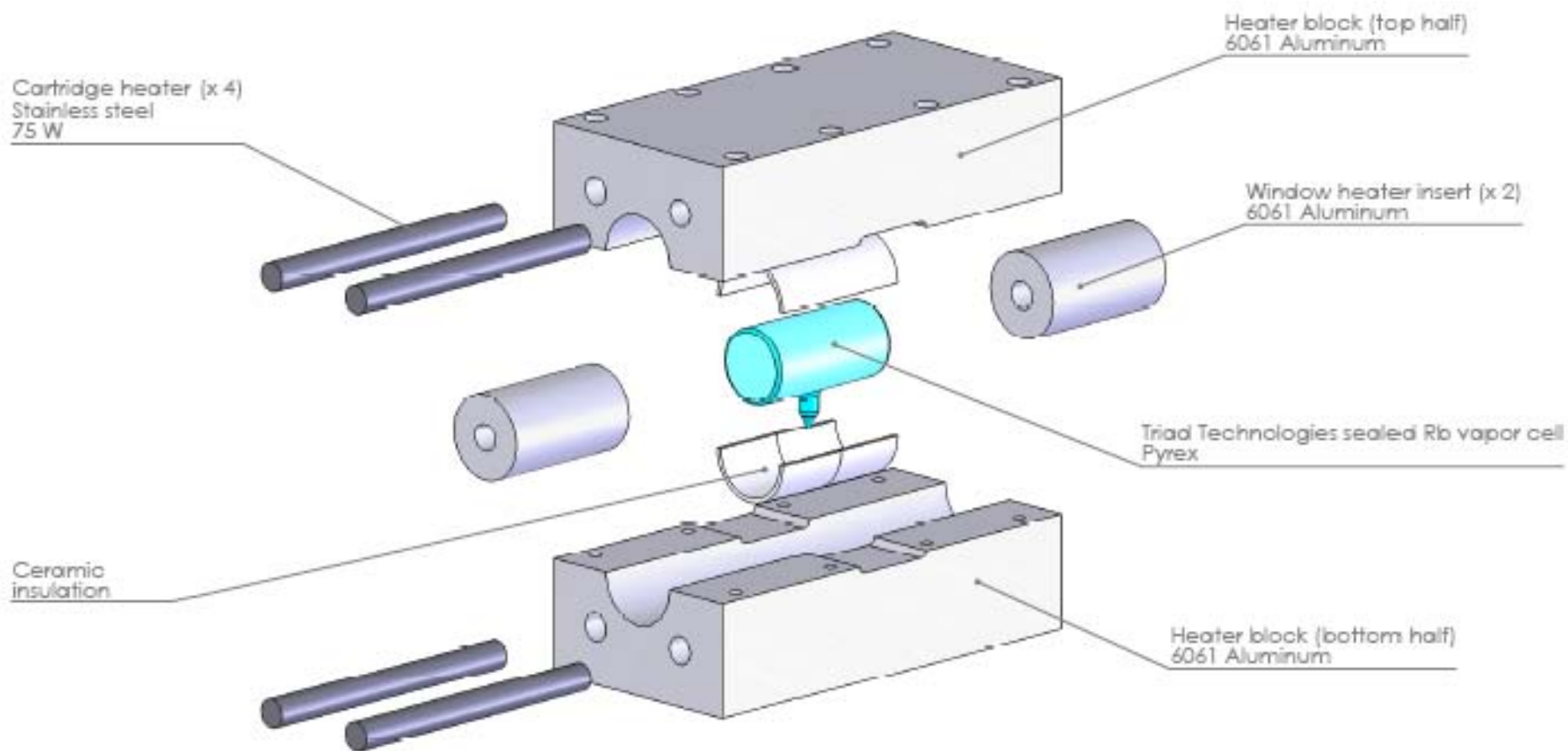
Cs-Ar Energy Level Diagram

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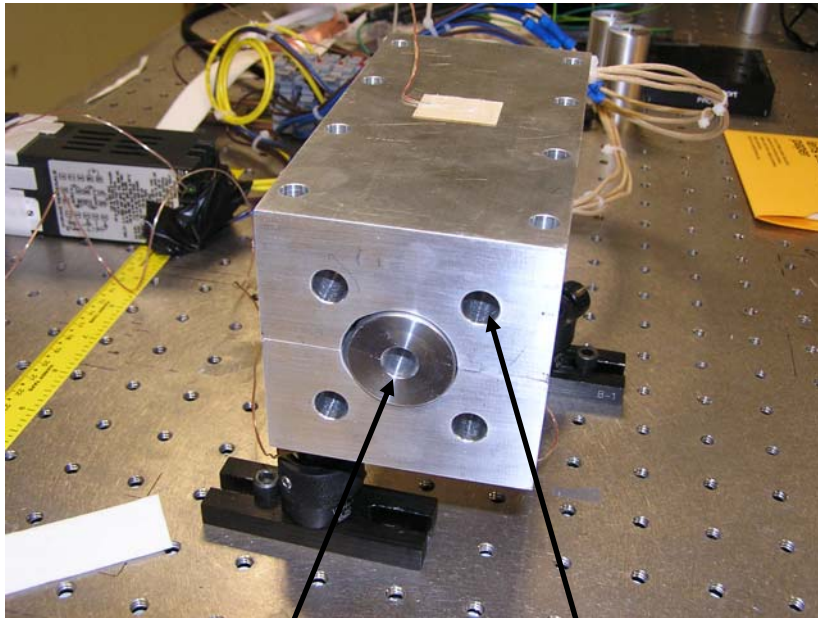
Alkali Cell Oven Design

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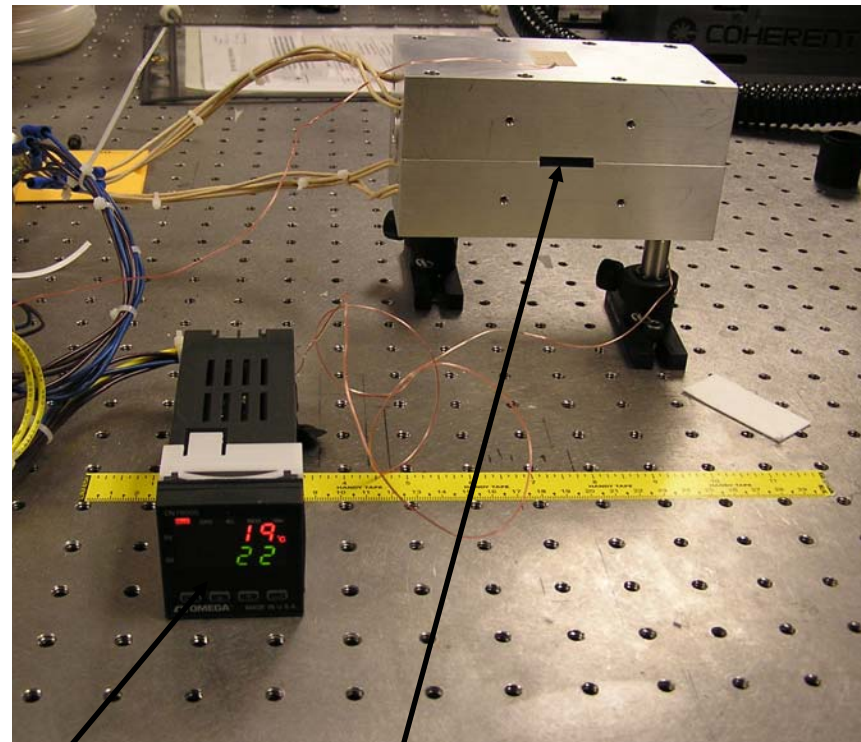
Assembled Alkali Cell Oven: Exterior

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**End View
Optical Access
Through Heated
Inserts**

**Cartridge
Heater
Ports (x 4)**

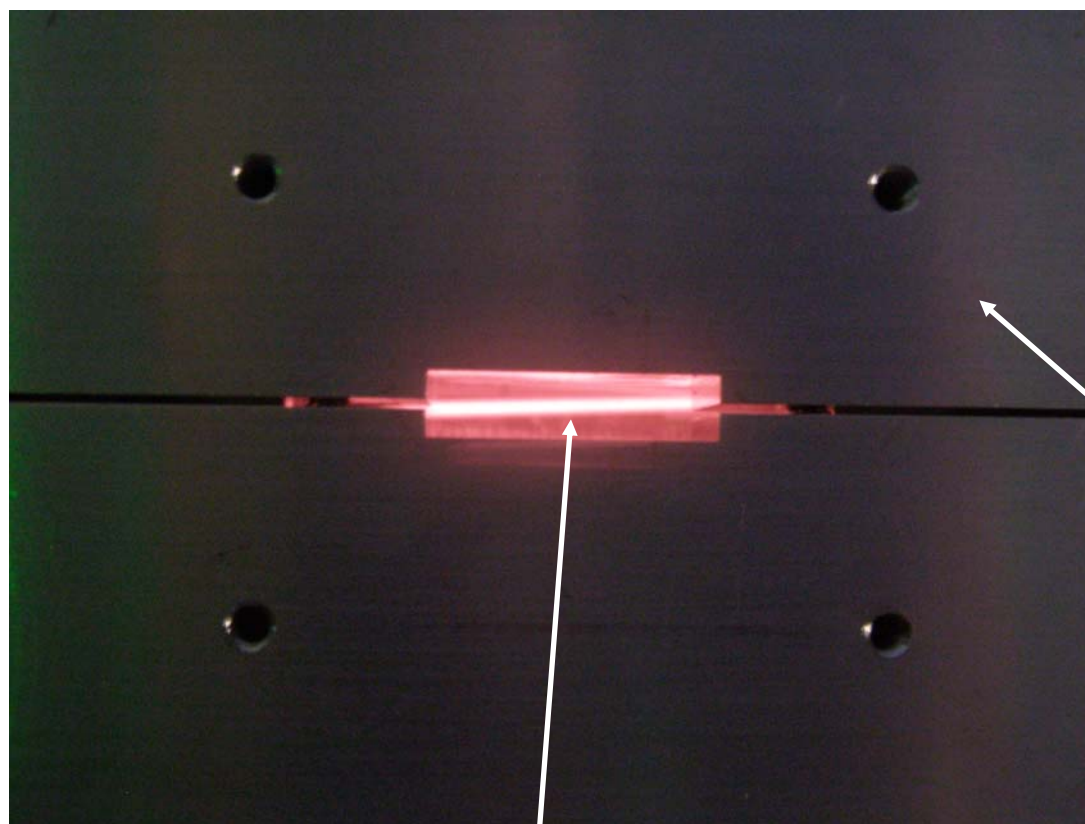


**Temperature
Controller**

**Side Port for OMA
Spectrometer
Diagnostic Access
and Side Pumping**

Photograph of Rb Atom Fluorescence Viewed Through the Alkali Atom Oven Side Port: $\lambda_{\text{excitation}}$: 780 nm

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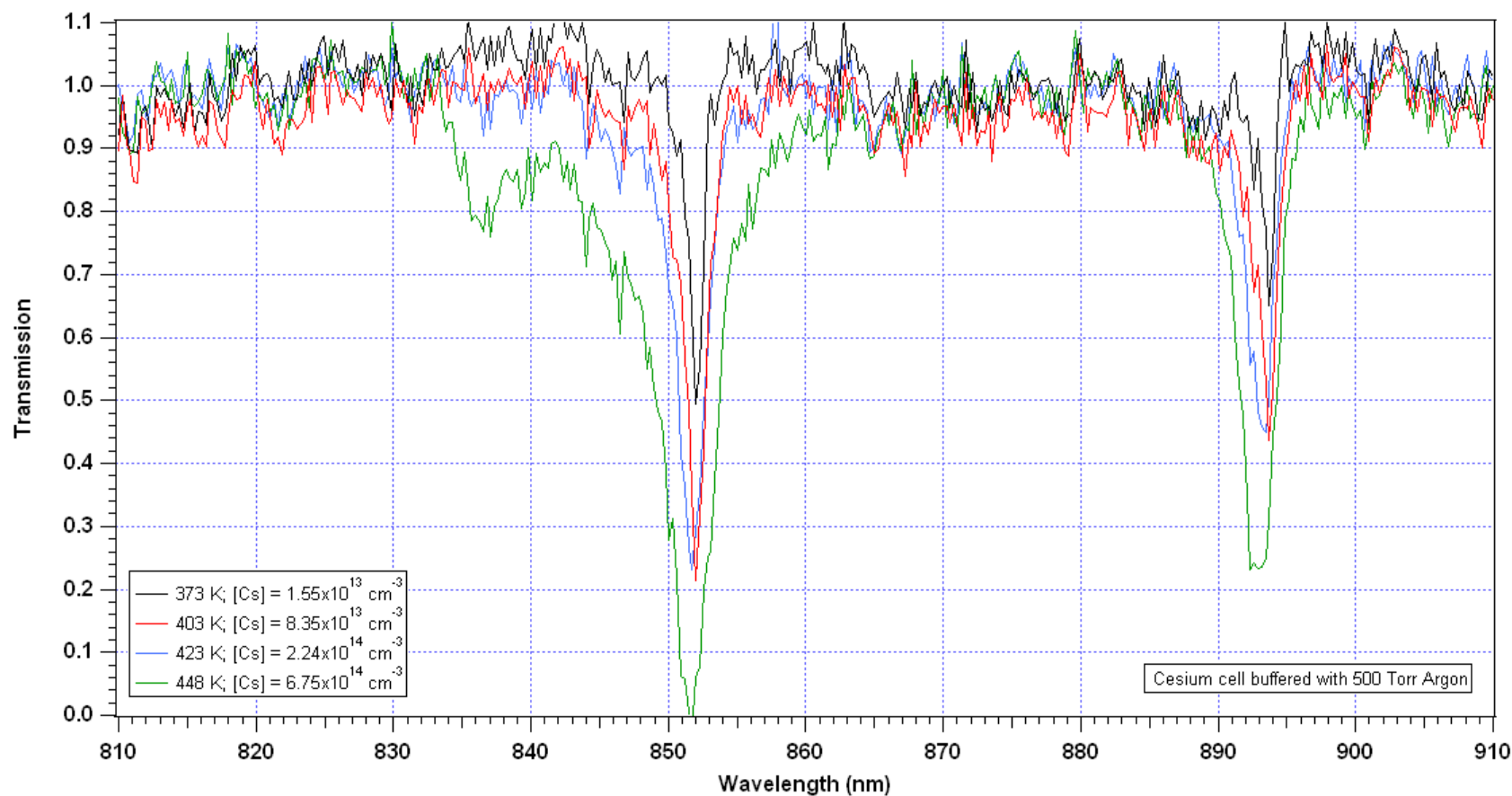


Alkali
Atom Oven

Rb Atom Side
Fluorescence

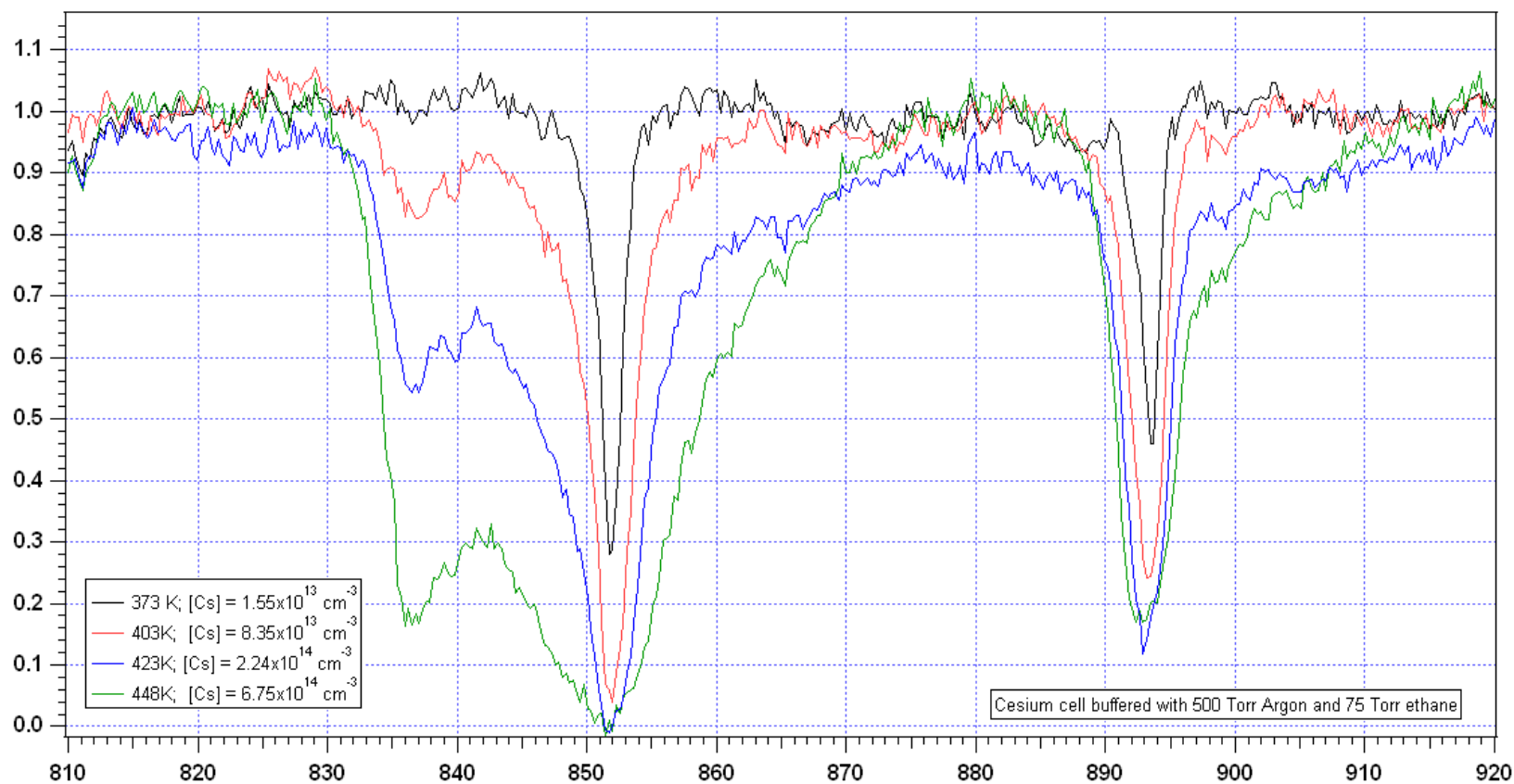
Absorption Spectra of Cs Buffered with 500 Torr of Ar

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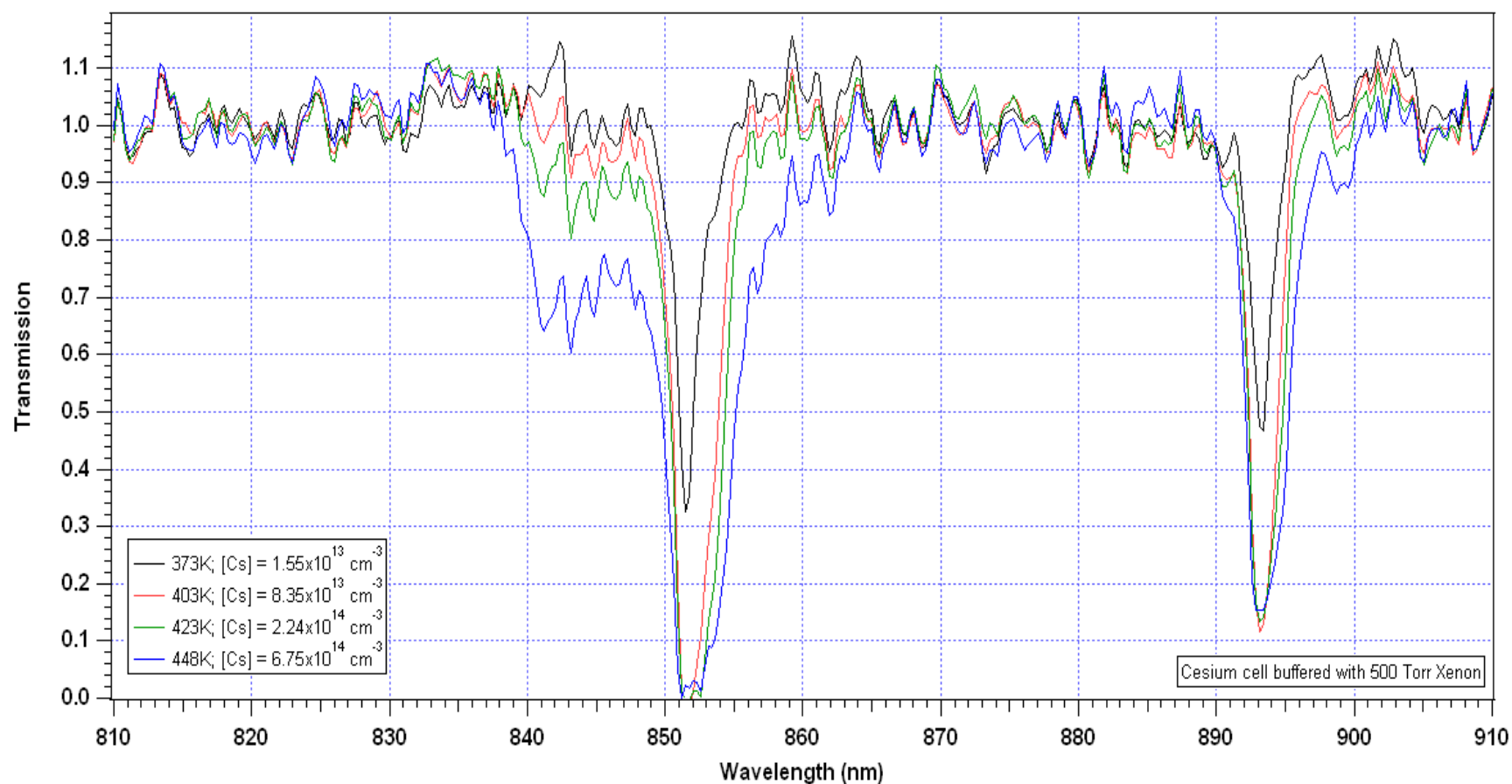


Absorption Spectra of Cs Buffered with 500 Torr of Ar and 75 Torr of Ethane

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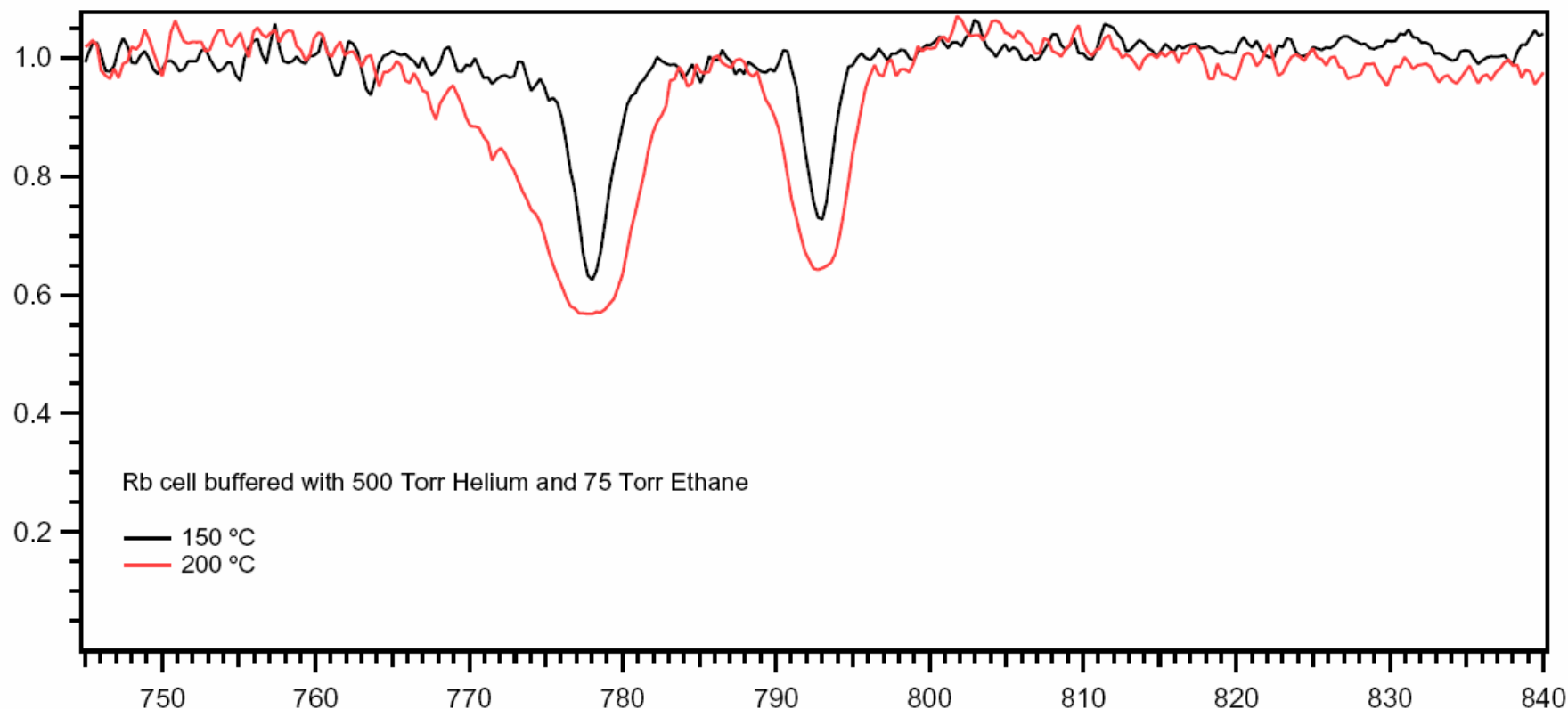


Absorption Spectra of Cs Buffered with 500 Torr of Xe



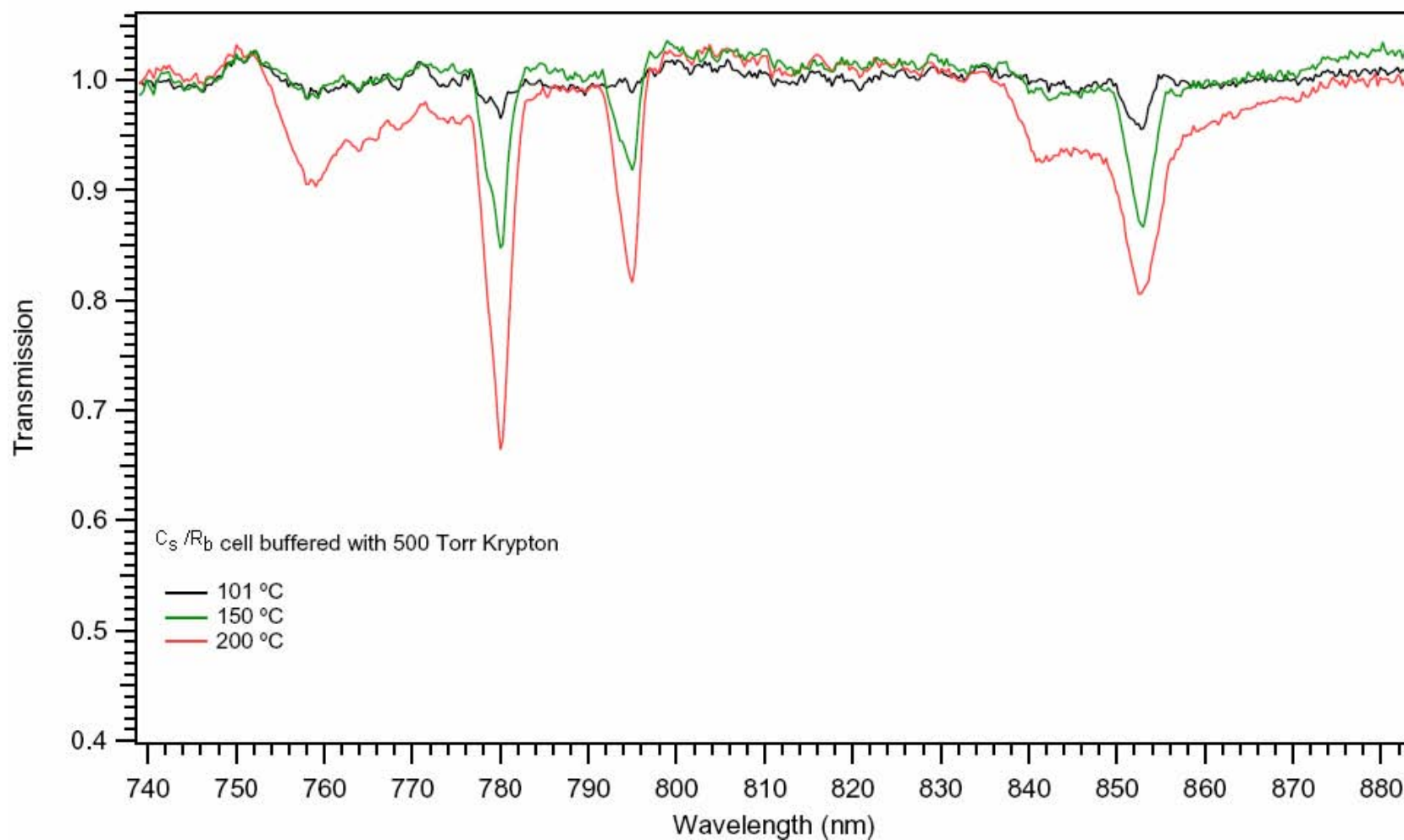
Temperature Dependant Absorption of Rb (Rb-He-Ethane Cell)

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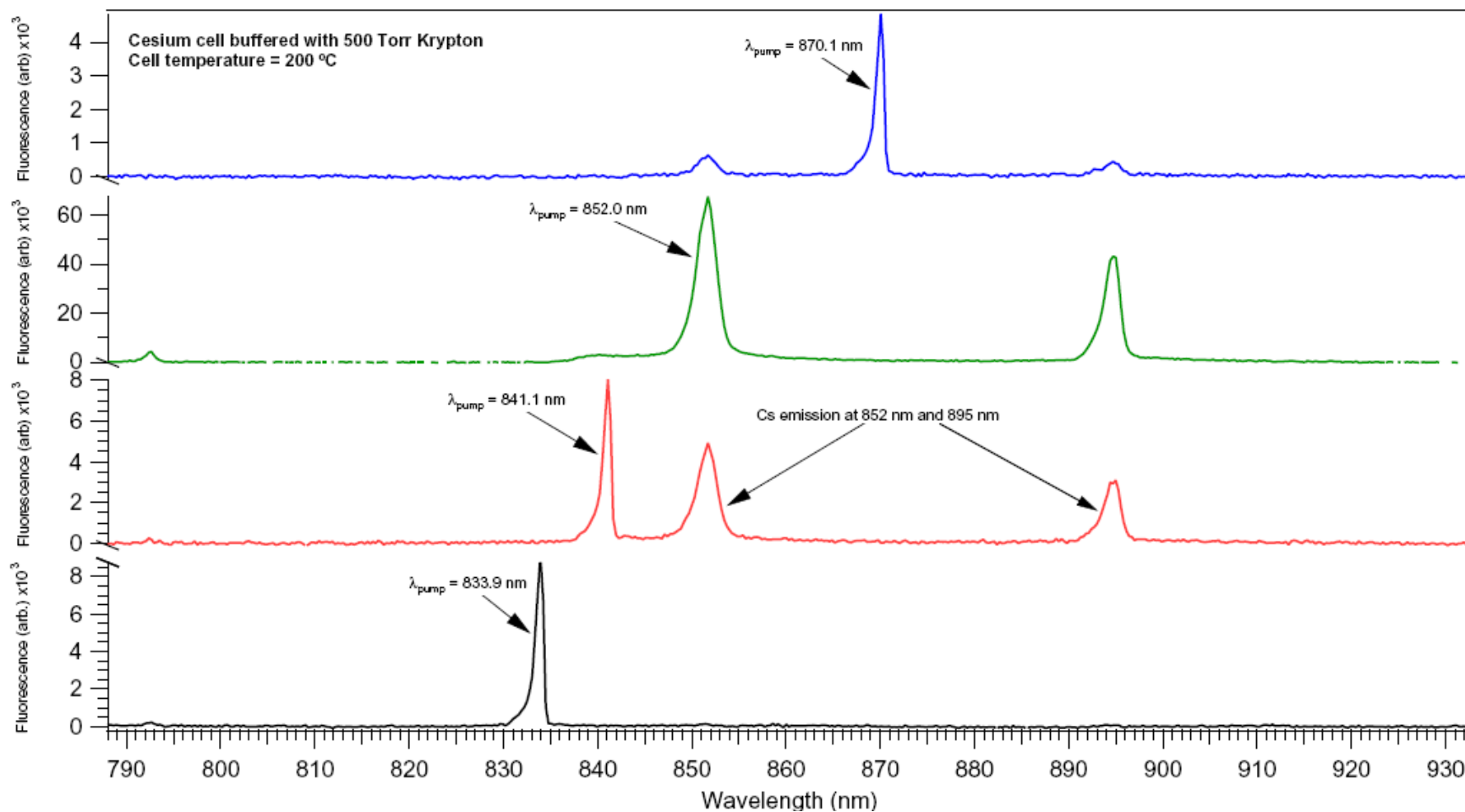
Temperature Dependent Rb–Kr and Cs–Kr Absorption Spectra

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Cs Atom Fluorescence Spectra as a Function of Excitation Wavelength

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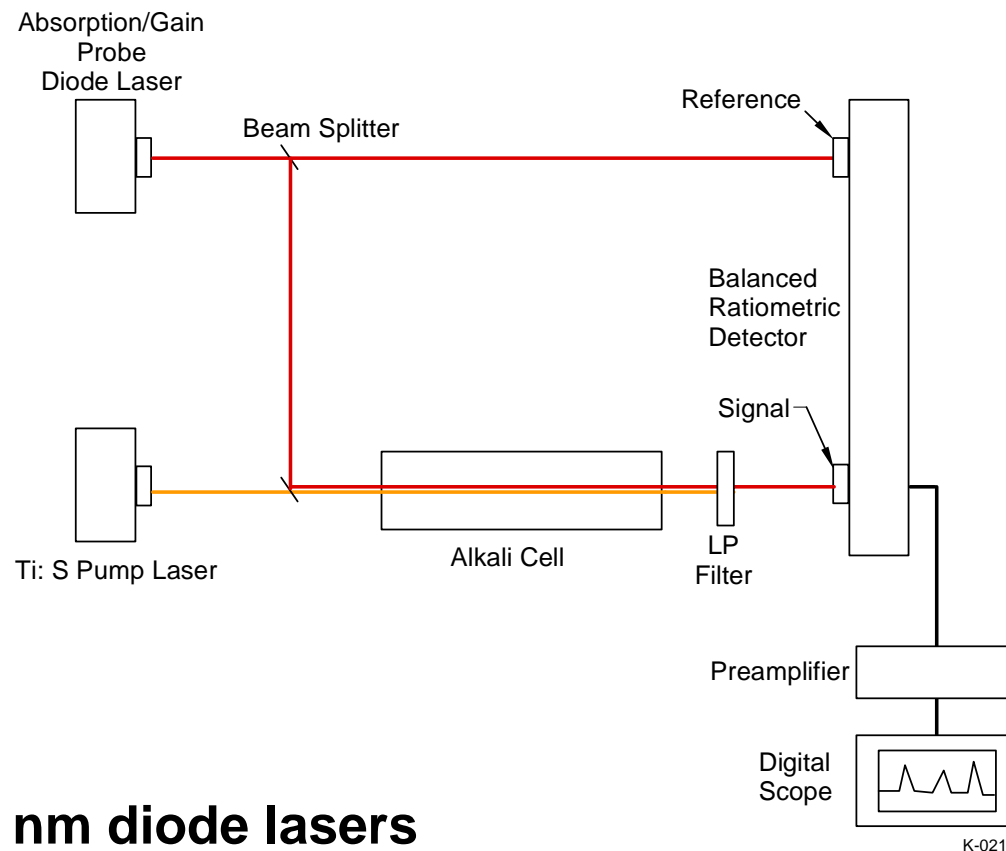
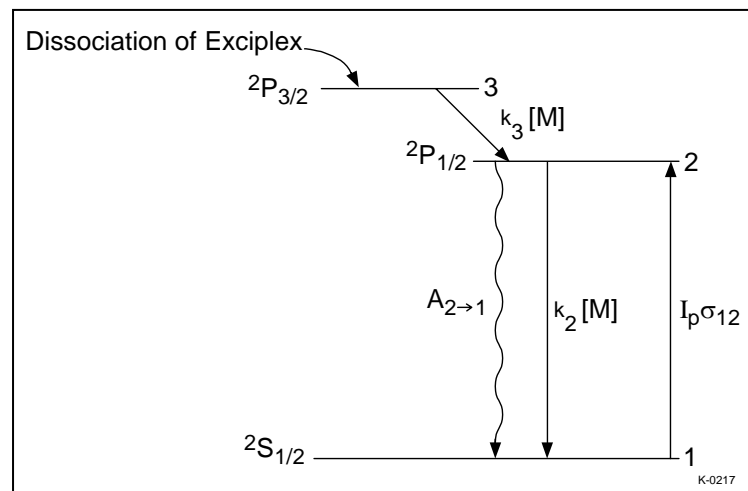
Experiments to Develop Kinetics Data for XPAL Based on Optical Gain

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- **Measurements will provide a key parameter concerning efficiency of XPAL process**
 - **Probe gain medium directly in absence of optical resonator**
 - **Provides information on population inversion and its sensitivity to pump laser intensity and wavelength, cell temperature, bath gas type and pressure**
- **Will enable design of optical resonators for optimal output coupling**
- **Portable system will be transportable to MRI partners' facilities for collaborative experiments**
- **Applicable to both CW and pulsed laser excitation configurations**

Experimental Setup for Gain Measurements in Optically Pumped Lasers

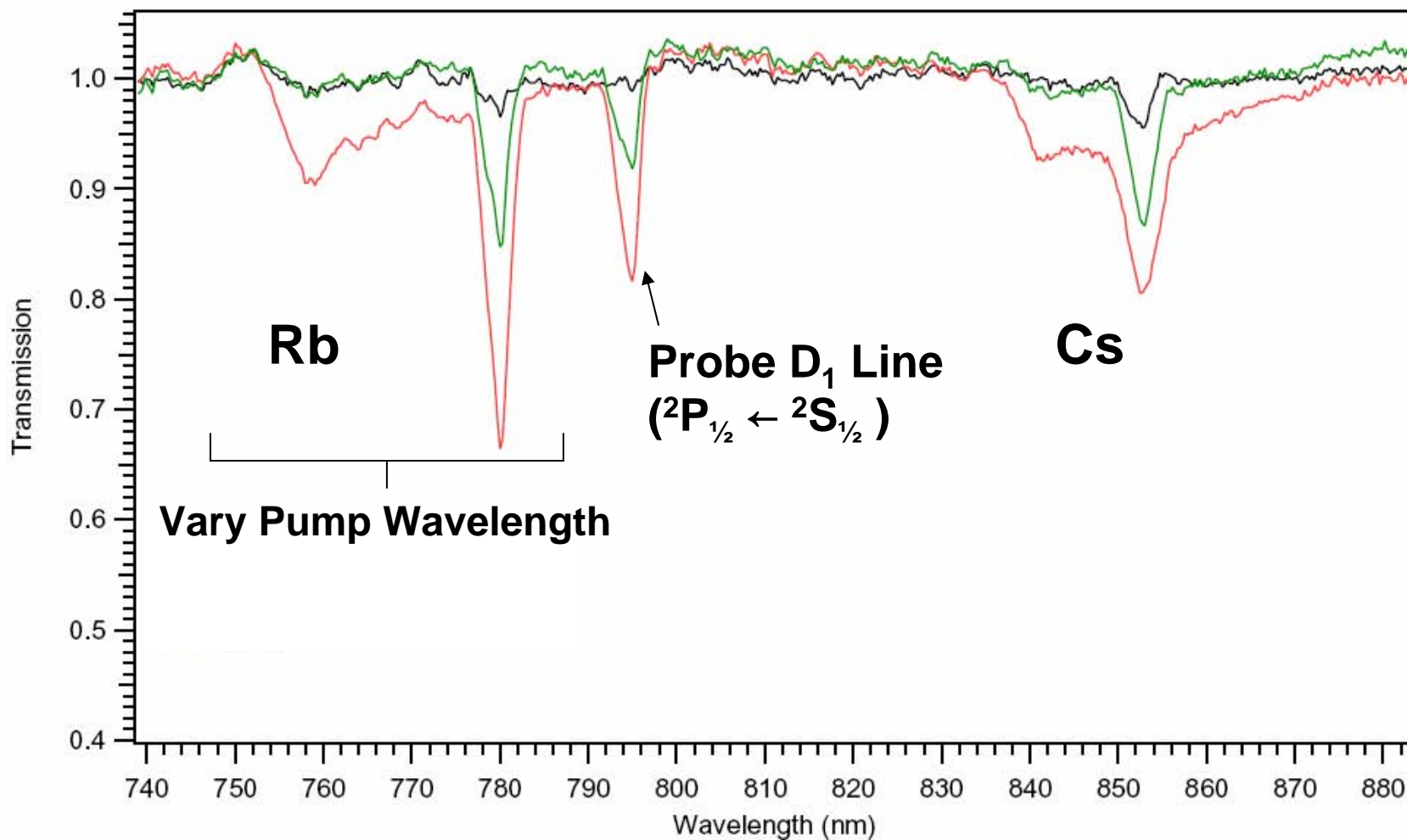
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- **For XPAL studies**
 - **Pump: Ti:S laser**
 - **Probe: 794 nm and 895 nm diode lasers**
 - **Portable systems; will be used at PSI and UIUC**

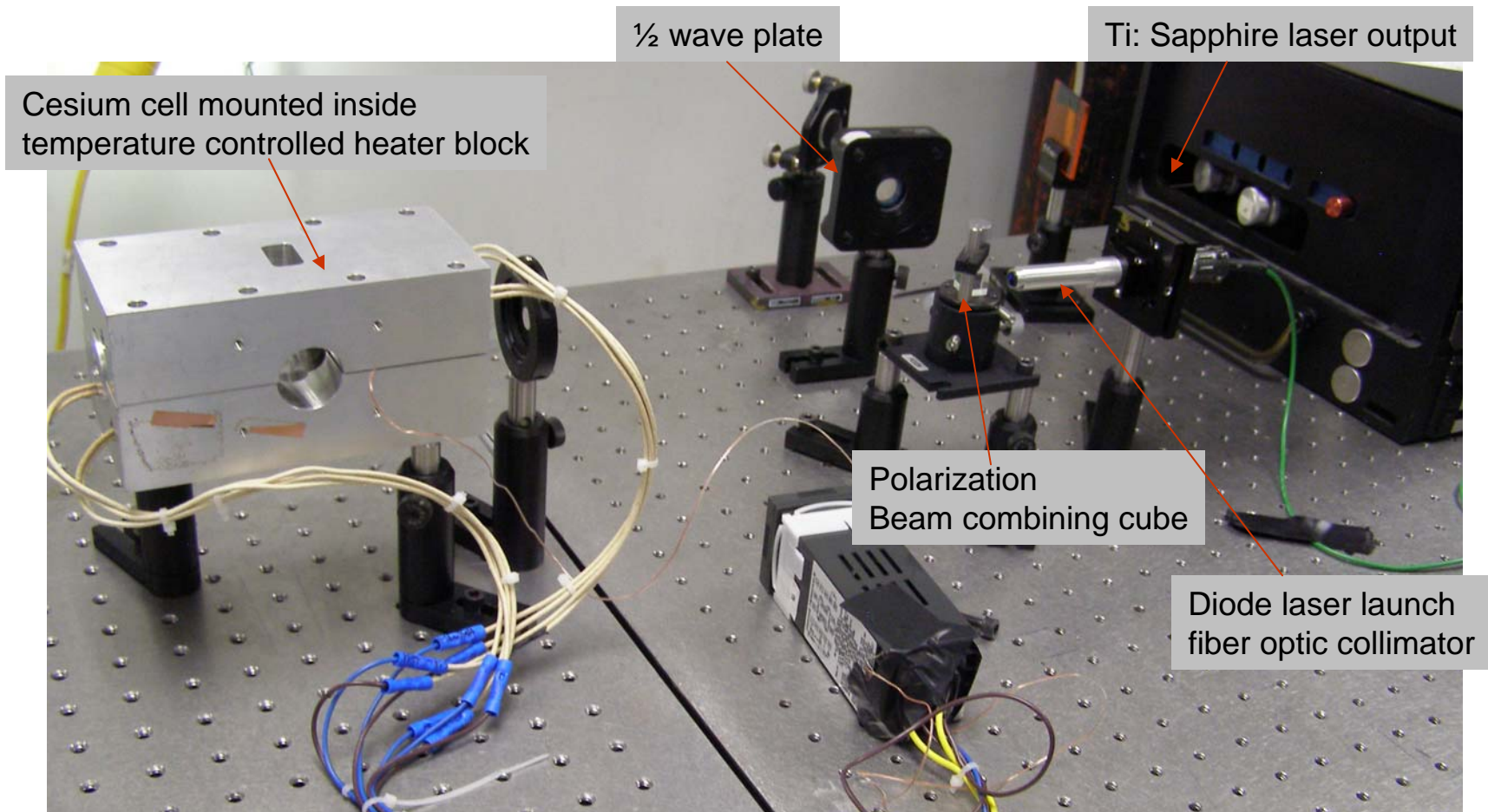
Strategy for XPAL Gain Measurements

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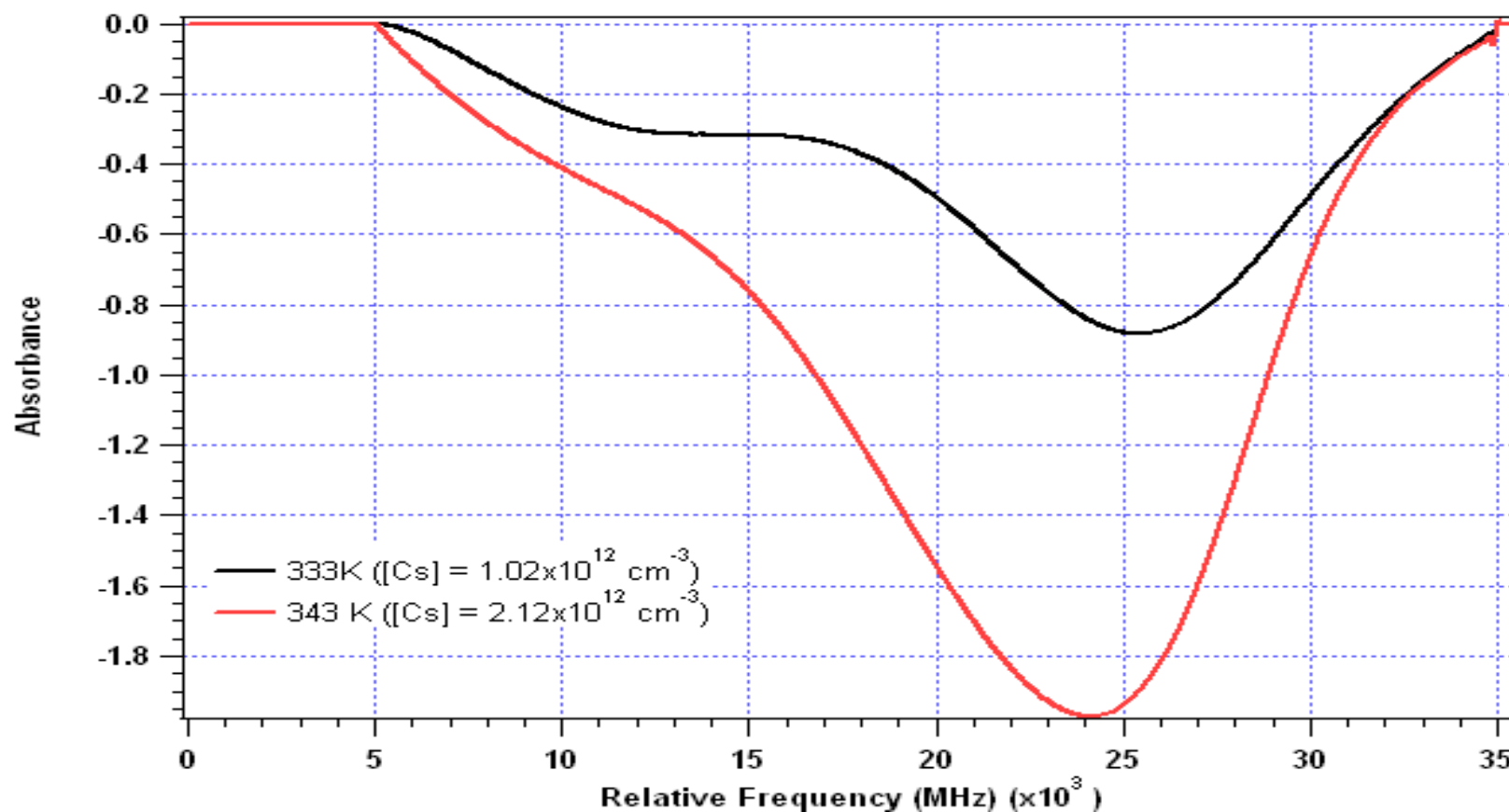


Experimental Setup for Initial Gain Probe Measurements

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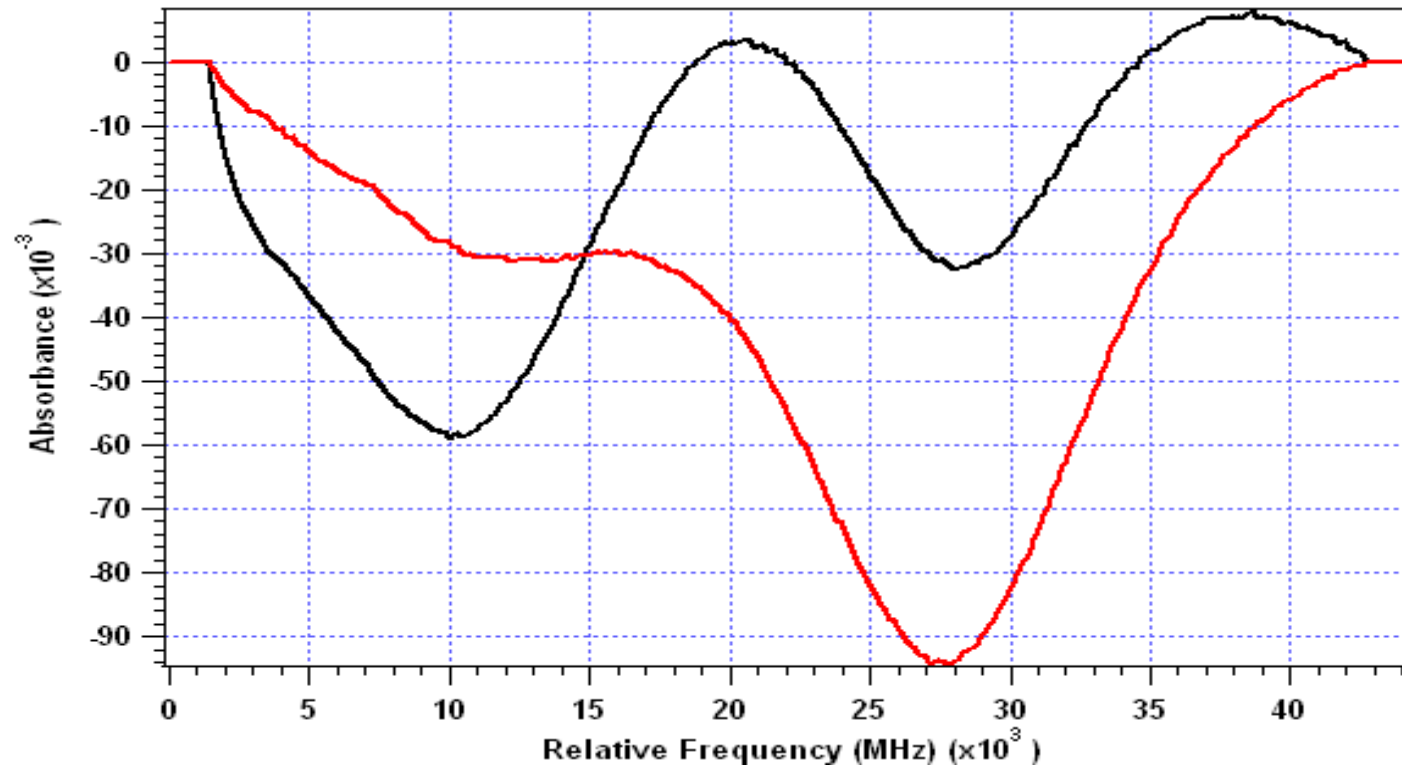


Absorption Spectrum of Cs D₁ line in CsKr Cell (no optical excitation by Ti:S laser)



Absorption and Gain Spectra for CsKr Cell

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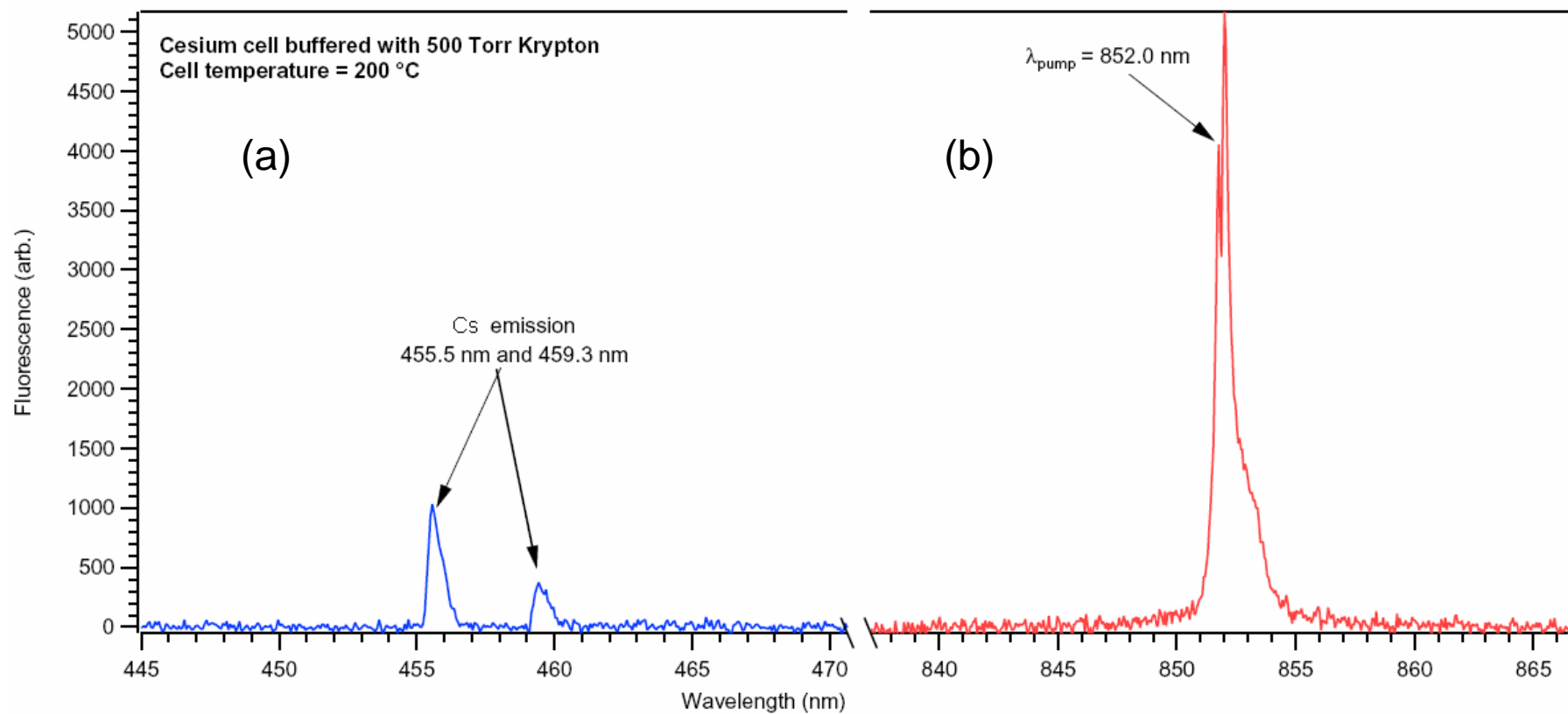


- Black Trace: Ti:S tuned to Cs D_2 line
- Red Trace: Ti:S laser tuned off the D_2 resonance

- These data confirm the approach
- Will develop key data base for both DPAL and XPAL pumping schemes

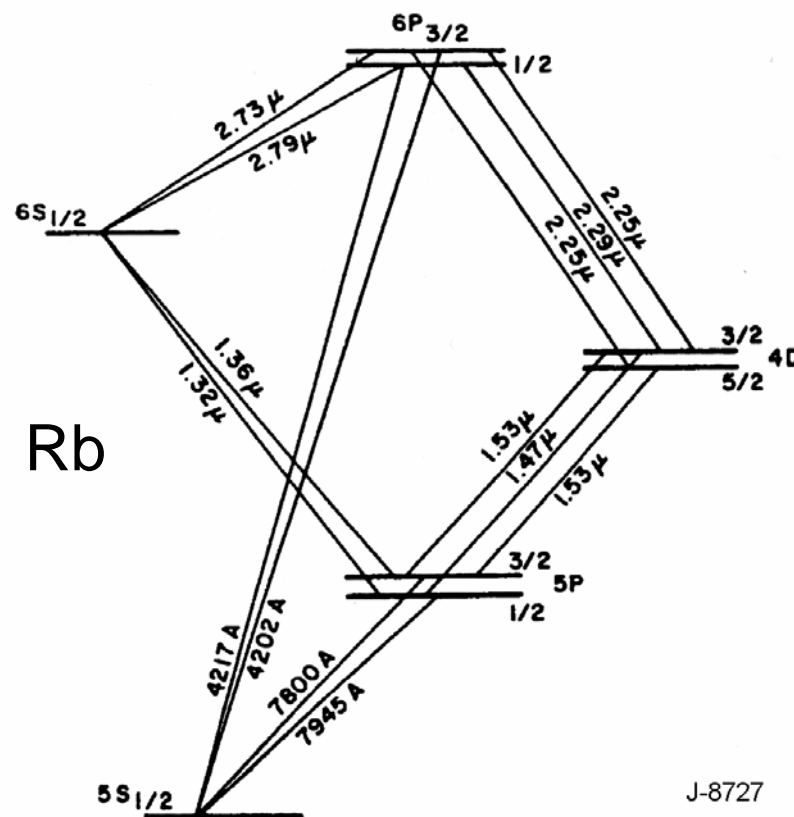
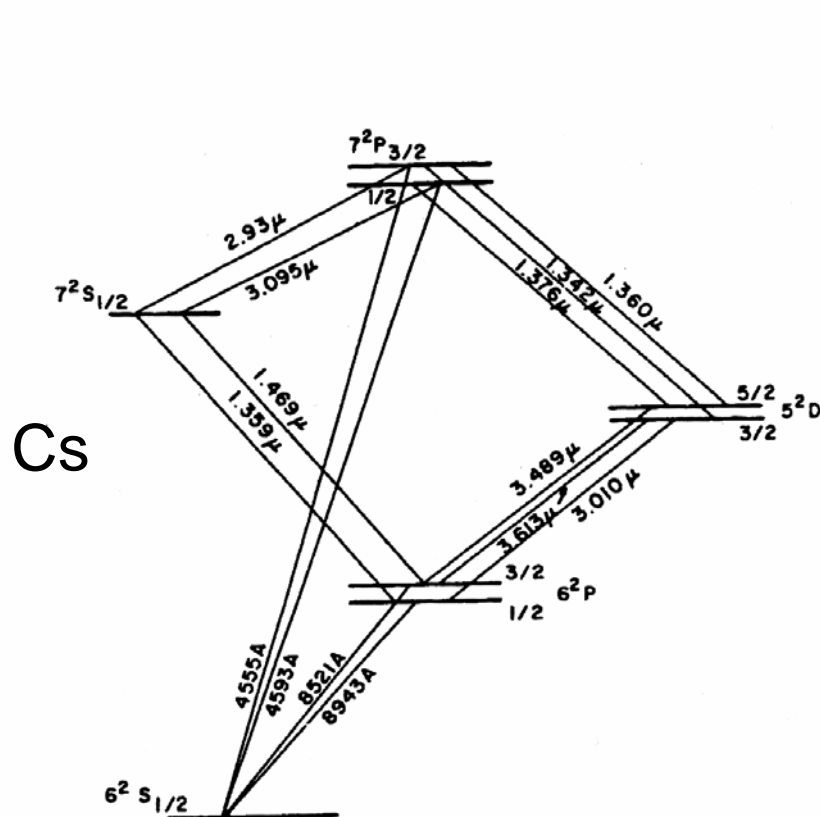
“Blue” Cs Doublet Emission at $\lambda_{\text{excitation}}$: 852 nm

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Energy Level Diagrams for Cs and Rb Showing the Ground $^2S_{1/2}$ State and Several Excited States Relevant to Alkali Atom Lasers

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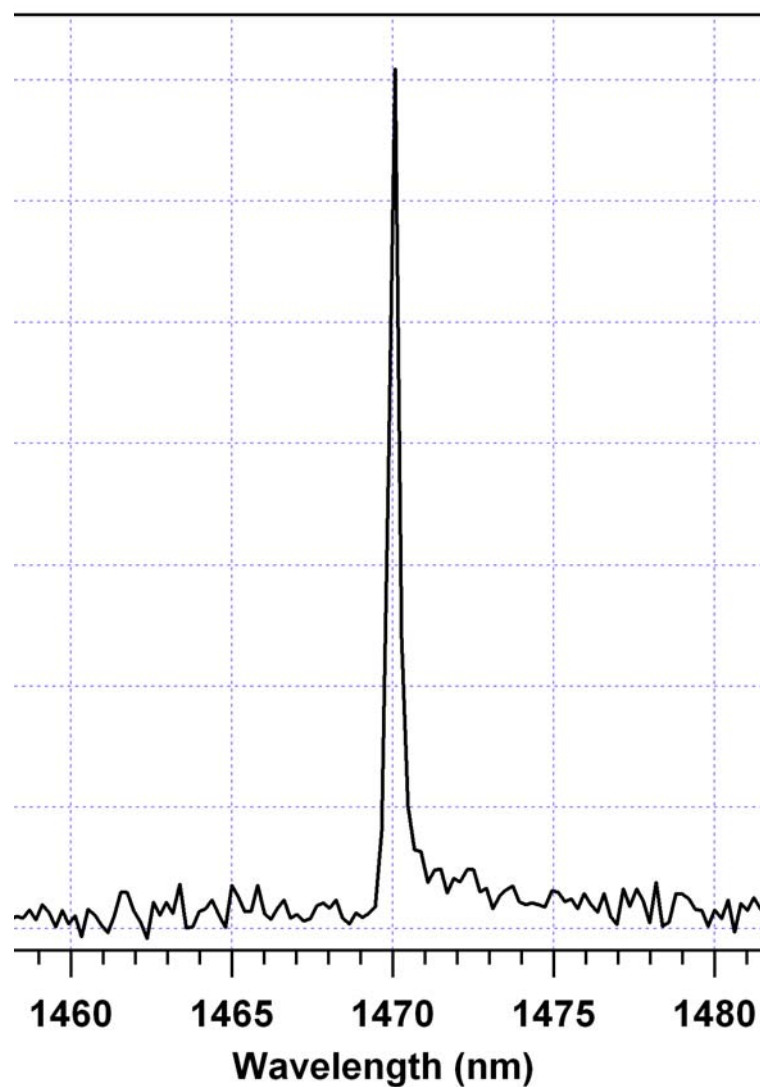


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From: Sharma *et al.* APL 39, 209 (1981)

Cs Near-IR Emission Line ($7 S_{1/2} \rightarrow 6 P_{3/2}$) ($\lambda_{\text{pump}} \sim 780 \text{ nm}$)

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Summary and Future Work

- **Demonstrated fluorescence at 852 and 894 nm when pumping in blue-wing of exciplex in Cs-Kr cell**
- **Measured absorption spectra in Cs-Kr and Rb-Kr cells**
 - Blue wings significant
- **Have observed blue fluorescence and IR fluorescence from higher lying states in both Rb and Cs excited at or near D₂ lines**
- **Developed gain diagnostic for alkali systems**
- **Continue work on side pumping and unstable resonator configurations**
- **Utilize high power Q-Peak diode laser system for Rb XPAL experiments**

Acknowledgements

M. C. Heaven, J. Merritt, J. Han
Emory University

**J. G. Eden, J. D. Readle, C. J. Wagner,
J. J. Coleman, N. L. Dias, V. B. Verma**
University of Illinois at Urbana-Champaign

J. T. Verdeyen, D. L. Carroll
CU Aerospace

**HEL-JTO
and
AFOSR**